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Potential Industrial Uses and Quality of Oil of Palm Weevil, *Rhynchophorus phoenicis* F. (Coleoptera: Curculionidae)

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Abstract. The study of the industrial potentials of the palm weevil revealed the water absorption capacity to range from 53.33% in the late larval stage (LLS) to 113.33% in adult stage (ADS) while oil absorption capacity varied from 87.97% in LLS to 121.33% in ADS. The adult had the highest emulsion capacity while none of the samples formed foams. ADS gelled at 4% while LLS and ELS (early larval stage) gelled at 10% and 16%, respectively. The oil had a specific gravity of 0.8742. Iodine and unsaponifiable matter were the highest in ELS, while LLS had the highest saponification value. ADS recorded the highest values for acid, free fatty acid, peroxide, slip point, melting point, softening point, smoke point, flash point and fire point. The anti-nutrient contents were generally low. Phytic acid was the highest in LLS, whereas, ADS had the highest oxalate and tannin contents.

Keywords: *Rhynchophorus phoenicis*, functional properties, physicochemical properties, smoke point, anti-nutrients

Introduction

Palm weevil (*Rhynchophorus phoenicis*) is one of the most notorious species of insect pests that attack all types of palms. Other species are *R. palmarum*, *R. ferrugineus*, and *R. bilineatus* (Grimaldi and Bikia, 1985). *R. palmarum* transmits red ring disease in palms (Morin *et al*., 1986; Hill, 1983). Apart from being pests, palm weevils and some other insects are attractive and are important natural sources of nutrients for humans in African, Asian and Latin American region (Chen and Akre, 1994; Fasoranti and Ajiboye, 1993; Sutton, 1988). Some examples of very important edible insects are grasshoppers, bees, ants and caterpillars of beetles (Adedire and Aiyesanmi, 1999; DeFoliart, 1992; Malaise and Parent, 1980). The quality of protein determines the functional capability of any food item (Kinsella, 1976). Insects are good sources of quality proteins that range between 60-70% (Stein, 1991).

Palm weevil is a good source of protein, minerals and fat. Larde (1989) reported that palm worms ranked higher to winged termites being the richest source of animal fat − a frequently scarce and needed commodity among tropical rural population. The physicochemical properties and the levels of anti-nutritional contents play vital role in the application of fat and oil in industries (Kinsella, 1979).

The present research work was conducted to determine the functional and the physicochemical properties as well as the level of anti-nutrients in the developmental stages of palm weevil.

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Materials and Methods

Insect collection. Palm weevil (*R. phoenicis*) larvae and adults were purchased from the main jetty terminal market at Igbokoda, Ondo State, Nigeria. The larvae were classified into early and late larval stages based on head capsule measurement, weight, body length, body width and circumference (Table 1). The larvae and adults were killed by asphyxiating them in a deep freezer for 48 h. The samples were dried separately in a Gallenkamp oven at 60 °C to a constant weight according to the procedure described by Adedire and Aiyesanmi (1999). The oil extracted during drying was put in a bottle and kept in the laboratory for analysis. The dried samples were pulverized with the laboratory pestle and mortar and stored in containers until required.

Functional analysis. Water and oil absorption capacities of the samples were determined as described by Coffman and Garcia (1977). The emulsion capacity was determined by the method of Yasumatsu *et al.* (1972) as described by Ige *et al.* (1984). The procedure of Coffman and Garcia (1977) as modified by Adeyeye *et al.* (2002) was used to determine the gelation properties, foaming capacity and the foaming stability of samples. Each parameter was measured in triplicate.

Determination of physicochemical properties. The specific gravity, refractive index, peroxide value and the free fatty acid value of the oil of *R. phoenicis* were determined according to Pearson (1976). The iodine value, saponification value, unsaponifiable matter and the acid values of the oil were estimated as described by Pearson (1981). The method recommended by AOAC (1975) was adopted in determining the melting point, the softening point, the smoke point, the flash point, the fire point and the slip point of the oil. All determinations were carried out in triplicate.

Anti-nutritional analysis. The estimation of phytin-phosphorus in the oil was determined by the colorimetric procedure of Reddy *et al*. (1978). Phytic acid was calculated by multiplying phytin-P by 3.55 as a factor (Enujiugha and Ayodele-Oni, 2003). Tannin was determined by the quantitative method of Markkar and Goodchild (1996). Oxalate content was estimated according to the procedure of Day and Underwood (1986). One gram of sample was added to 1.5N H_2SO_4. The solution was stirred carefully and intermittently with a magnetic stirrer for 1 h and then filtered using Whatman # 1 filter paper. 25 ml of the filtrate was titrated against hot (90 °C) 0.1N $KMnO_4$ solution till faint pink colour persisted for at least 30 sec. Each experiment was carried out in triplicate.

Results and Discussion

The dimensions of the larvae and adult palm weevils used for this study are presented in Table 1. The functional properties of the developmental stages of the weevil are presented in Table 2. The water absorption capacity of the oil was lowest in LLS and highest in ADS stage (53.33% and 113.33%, respectively). The least oil absorption capacity of 87.97% was observed in LLS stage. Water and oil absorption capacities of ELS and ADS are significantly different (P = 0.05) from those of LLS. The emulsion capacities of ELS, LLS and ADS were 50.25%, 50.33% and 48.51%, respectively. Emulsion stability was the highest in ELS (50.67%), while that in LLS and ADS was 50.33% and 50.13%, respectively. None of the developmental stages lather when homogenized, being very rich in fats. The least gelation concentration observed in the samples indicated that ELS gelled at 16%, while LLS and ADS gelled at 10% and 4%, respectively.

The water absorption value recorded for ELS stage is lower than that obtained in some common oil seeds. Oshodi (1992) reported the value of 175.0% and 130.0% for hulled and dehulled *Adenopus breviflorus* seeds, respectively. Water absorption capacity of 87.50 ± 0.0%, reported by Adeyeye *et al.* (2002) for *Parkia biglobosa* is higher than the value observed in LLS stage, while the value of 113.33 ± 5.78% reported for ADS stage is higher than the value reported for *Telfairia occidentalis* by Fagbemi and Oshodi (1991). Higher water absorption capacity is useful in food formulations such as bakery products where hydration improves handling characteristics. The least oil absorption capacity observed in LLS stage compares favourably with the value reported for *Cajanus cajan* seeds (89.70%) by Oshodi and Ekperigin (1989). Oil absorption capacity of ELS stage (112.33%) compares with the value reported for unfermented African oil bean, *Pentaclethra macrophylla* as 88%-195% (Akubor and Chukwu, 1999). The emulsion capacities of the developmental stages are higher than the values reported for *T. occidentalis* (20%) and *Sesamum indicum* (27.60%) by Badifu and Okpagher (1996) and Fagbemi and Oshodi (1991). The higher quantity of oil present in the weevil hinders foam formation. Foam

Table 1. Dimensions of the larval and adult stages of *R. phoenicis*

Sample	Weight (g)	Body length (cm)	Body width (cm)	Head region (cm)	Circumference (cm)
ELS	2.59 ± 0.140	2.54 ± 0.038	0.77 ± 0.038	0.65 ± 0.037	3.07 ± 0.055
LLS	8.14 ± 0.140	4.61 ± 0.063	2.05 ± 0.036	1.10 ± 0.013	5.47 ± 0.076
ADS	6.98 ± 0.132	5.70 ± 0.041	1.59 ± 0.021	2.88 ± 0.049	4.49 ± 0.037

each value is a mean ± standard error of the mean

Table 2. Functional properties of larval and adult stages of *R. phoenicis*

Properties	ELS (%)	LLS (%)	ADS (%)
Water absorption capacity	93.33 ± 5.78^b	53.33 ± 5.78^a	113.33 ± 5.78^b
Oil absorption capacity	112.33 ± 4.30^b	87.97 ± 5.25^a	121.33 ± 5.25^b
Emulsion capacity	50.25 ± 0.70^a	50.33 ± 0.20^a	48.51 ± 0.40^a
Emulsion stability (2 h)	50.67 ± 0.83^a	50.33 ± 0.54^a	50.13 ± 0.63^a
Foaming capacity	ND	ND	ND
Least gelation	16	10	4

means followed by the same letter within the row are not significantly different from each other (P = 0.05) by Tukey's test; ND = not deected formation and foam stability are a function of the type of protein, pH, processing methods, viscosity and surface tension (Yasumatsu *et al.*, 1972). The result of gelation reveals that all the developmental stages are good gel forming agents. However, ADS is the best gelling/firming agent with a value of 4%. All these values are better than those reported by Fagbemi and Oshodi (1991) for *T. occidentalis* (36%). All the developmental stages of the weevil would be useful as firming/gelling agents in food industries for the production of puddings, cakes, cheese and snacks which require thickening and gelling.

Physicochemical properties of the samples are depicted in Table 3. The colour of the sample oil extracts is brown. Specific gravity of the oil samples at 35 °C for all the stages are not significantly different (P = 0.05) from each other, whereas the refractive index of the oil could not be detected because it solidified readily making the recording impossible with refractometer. ADS recorded the lowest iodine value of 11.35 Wijis and ELS, the highest value of 24.18 Wijis, while LLS recorded 19.11 Wijis. The values of free fatty acids and the peroxide increased from ELS to ADS stages. The highest saponification value of 81.35 mg KOH/g was observed in LLS, while ELS and ADS recorded 53.53 and 44.88 mg KOH/g, respectively. ELS contained the highest value of unsaponifiable matter (99.23 mg KOH/g), while LLS, the lowest value of 96.63 mg KOH/g. The melting point, the softening point, the smoke point, the flash point and the fire point increased slightly from ELS to ADS stage. While there are no significant differences (P = 0.05) in the slipping, melting and softening points of all the developmental stages, the smoke and the flash points of ADS are significantly different (P = 0.05) from those of ELS and LLS.

Specific gravity of oil (0.8742 g/ml) is comparable to the values obtained for lard (0.0404-0.8960 g/ml) and tallow (0.8470-0.8980 g/ml) by Usoro *et al.* (1982). The oil is saturated one, hence it solidifies easily. It is thus suitable for candle making. The refractive index of 1.454 has been reported for butterfat by Pearson (1976), while the values of 1.448-1.460 and 1.443-1.460 have been reported for the lard and the tallow, respectively, by Usoro *et al.* (1982). The iodine values of the samples are lower than those quoted for butterfat (36 Wijis), lard (45-70 Wijis) and tallow (32-50 Wijis) by Pearson (1976). The values of fatty acid in the samples are higher than those for lard (1.3 mg KOH/g) and tallow (2.5 mg KOH/g). Fatty acid value is important in determining the use of oil for industrial and edibility purposes (Amoo and Moza, 1999). Fatty acids are necessary for correct formation of nerves, brain tissue and the retina of eyes. The value of unsaponifiable matter observed in LLS is the lowest whereas the values present in ELS and ADS are comparable. The values of 10 g/kg and 12 g/kg have been reported for lard and tallow (Pearson, 1976). Khor *et al.* (1998) reported that virgin olive oil contains 1.036% unsaponifiable matter. The unsaponifiable matters of olive oil had cholesterol-lowering effect when fed to rats (Huang *et al.*, 1991). The importance of using unsaponifiable matter for reducing plasma cholesterol has been emphasized in hamsters (Kahlon *et al.*, 1996). The results of the melting, softening, smoke, flash and fire points show that the oil of the weevil would be highly desirable for

Table 3. Physicochemical properties of larval and adult stages of *R. phoenicis*

Components	ELS	LLS	ADS
Colour	Brown	Brown	Brown
Specific gravity g/ml (at 35 °C)	0.8742 ± 0.00[a]	0.8742 ± 0.00[a]	0.8742 ± 0.00[a]
Refractive index (at 35 °C)	ND	ND	ND
Iodine value (Wijis)	24.18 ± 1.09[c]	19.11 ± 0.32[b]	11.35 ± 0.12[a]
Acid value (mg KOH/g)	2.81 ± 0.003[a]	2.82 ± 0.02[a]	3.33 ± 0.05[b]
Free fatty acid value (mg KOH/g)	1.88 ± 0.01[a]	1.91 ± 0.003[a]	2.05 ± 0.06[b]
Peroxide value (mg KOH/g)	2.01 ± 0.01[a]	2.22 ± 0.06[a]	4.32 ± 0.40[b]
Saponification value (mg KOH/g)	53.53 ± 0.41[b]	81.35 ± 1.40[c]	44.88 ± 1.40[a]
Unsaponifiable matter (mg KOH/g)	99.23 ± 0.03[b]	96.63 ± 0.15[a]	99.21 ± 0.16[b]
Slip point (°C)	34.67 ± 0.58[a]	34.33 ± 0.58[a]	35.33 ± 0.58[a]
Melting point (°C)	44.00 ± 1.00[a]	44.00 ± 1.00[a]	45.00 ± 1.00[a]
Softening point (°C)	53.33 ± 1.50[a]	53.55 ± 0.58[a]	54.00 ± 1.00[a]
Smoke point (°C)	145.33 ± 0.58[a]	147.33 ± 0.47[b]	149.33 ± 0.58[c]
Flash point (°C)	159.00 ± 1.50[a]	159.67 ± 0.58[a]	162.33 ± 1.00[b]
Fire point (°C)	178.00 ± 2.00[a]	178.67 ± 1.15[a]	179.67 ± 0.58[a]

means followed by the same letter within the row are not significantly different from each other (P = 0.05) by Tukey's test; ND = not detected both the domestic and the industrial purposes. Higher value of the fire point indicates that the oil could be employed in the frying of food substances that require higher temperatures. Moreover, the incidences of fire outbreaks at homes as a result of oil catching fire could highly be eliminated if the oil from palm weevils is used.

The levels of anti-nutrients in *R. phoenicis* are presented in Table 4. The highest concentration of phytic acid (4.94 mg/100 g) was observed in LLS, while ELS and ADS both had 4.12 mg/100 g. The oxalate content ranged from 1.35 mg/100 g in ELS to 3.63 mg/100 g in LLS, while ADS had the highest value of 7.29 ± 0.09 mg/100 g. The tannin contents of the samples ranged from 0.85% in LLS to 0.93% in ELS, while ADS had the highest value of 1.73 ± 0.09%. The tannin content of ADS is significantly different (P = 0.05) from that of ELS and LLS.

Table 4. Anti-nutrient composition of larval and adult stages of *R. phoenicis*

Parameter	ELS	LLS	ADS
Phytic acid (mg/g)	4.12 ± 0.01[a]	4.94 ± 0.01[b]	4.12 ± 0.02[a]
Oxalate (mg/g)	1.35 ± 0.09[a]	3.63 ± 0.05[b]	7.29 ± 0.09[c]
Tannin (mg/g)	0.93 ± 0.02[a]	0.85 ± 0.01[a]	1.73 ± 0.17[b]

means followed by the same letter within the row are not significantly different from each other (P = 0.05) by Tukey's test

The values of phytic acid in the samples are similar to that reported by Enujiugha and Ayodele-Oni (2003) for African oil bean seeds (4.10 mg/100 g) but lower than that of *Dioclea reflexa* (318.40 mg/100 g) (Aiyesanmi and Oguntokun, 1996). Legumes are particularly rich in phytate, which significantly reduces the overall availability of certain minerals found in them (Balogun and Fetuga, 1986). The oxalate content of ADS is higher than that of castor bean seeds (6.5 mg/100 g) and conophor nuts (3.60 mg/100 g) (Enujiugha and Ayodele-Oni, 2003). The tannin content of 151.80% was reported by Aiyesanmi and Oguntokun (1996) for *D. reflexa* and 0.15 g/kg and 0.11 g/kg for locust bean and melon seeds, respectively, by Enujiugha and Ayodele-Oni (2003). The anti-nutrient properties of *R. phoenicis* (Table 4) indicate that this insect has better nutritive values than pulses, which contain higher level of tannins, oxalates and phytic acids that are known to affect the digestibility of proteins, carbohydrates and fats and also affect the bio-availability of minerals. However, tannin is useful in tanning leather, dyeing fabric and can also be used for making ink.

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